Lab 1 – DT signals, LTI systems, frequency

Entry test example questions

1. Check linearity of a system given by equation: ....*substitute any example from lecture here*
2. Check stability of a system given by equation: ....
3. Calculate convolution of two signals given by set of samples or given by simple expression (e.g. with $\delta's$)
4. $x_a(t) = cos(2\pi f_a t)$ was sampled with sampling period T_s. Find normalized frequency, normalized angular frequency θ or period of the sampled signal. Plot the (sampled) signal spectrum. (f_a, T_s or f_s given, their proportion rational or irrational...)
5. An analog signal with spectrum extending from $-f_a$ to $+f_a$ has been sampled with a sampling period T_s (or frequency f_s). Plot the spectrum after sampling (different values of f_a w.r.t. f_s)

Matlab notes

For help, use `help <subject>`, note that UPPERCASE is used to mark keywords in help only, not in real usage in Matlab....

For plotting DT signals, use markers (`plot(n,x,'o')` or '-o'). For the continuous couterparts, use lines.

Exercises

Italics denote optional tasks.

1. NOT using Matlab, plot (with a pen or pencil) two periods of 200 Hz sine wave sampled at 2 kHz. Note number of samples per period.
2. Using Matlab `sin()` function, try to repeat the picture on screen plot. Finally extend the plot to 100 samples length (with the same parameters). (Then, show your result to the teacher.)
3. Applying `sign(x+eps)` to your signal `x` obtain a square wave and plot it. (hint: `eps` is added to avoid exact zero in `x` being converted to zero - square wave is either +1 or -1).

4. Use A/D converter to get signals (as in 3 and 1) from a generator. Compare simulated and real-world plots. Use Matlab's command: `y=getdata(Nsamples_in_block, [Kblocks, [Tsampling, [leave_bias]]])` (Tsampling is in seconds, "[ ]" denote optional arguments).

5. Label an x-axis of above plot with time units, then repeat with sample indices (hint: `plot(xvalues, yvalues, 'marker');`).

6. write m-files implementing lecture examples of DT systems:

multiplier	$y(n) = 3 \cdot x(n)$
two sample averager	$y(n) = \frac{x(n)+x(n-1)}{2}$
M sample averager	$y(n) = \frac{1}{M}\sum_{k=0}^{M-1} x(n-k)$
compressor	$y(n) = x(Mn)$
FIR filter	$y(n) = \sum_{k=0}^{M} h(k) \cdot x(n-k)$
square value	$y(n) = (x(n))^2$

   Note: FIR filter is a lecture example limited to finite length $h[k]$

7. Make some experiments testing L and TI properties of above systems.

8. Plot impulse responses of all systems of item 6

9. Implement an accumulator and test it with $\delta[n]$ and $u[n]$.

10. Implement $y(n) = a \cdot y(n-1) + x(n)$, accepting a and initial y as parameters. Test impulse response with zero initial condition, initial cond. response, then the combination of both for $0 < a < 1$.

11. Experiment with different values of a.

12. *Implement "from scratch" a convolution of two series. Compare results with `conv`. Check timing (`help etime`), and `flops`*

13. Use convolution (`conv()`)to find a response of an M sample averager to a sequence with four nonzero samples. Check results against the implementation of item 6. *If you have tried 12, compare timing of your and system implementations*

14. *The same with system of item 10. Q: can you do it exactly?*

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